GLACIER CORNICES.

In recording observations concerning the glaciers of Greenland, Professor T. C. Chamberlin[1] describes a jutting of certain layers of clear ice over dirt-stained layers in the vertical escarpment at the lower end of Tuktoo glacier. The projections or cornices referred to overhang from a few inches to ten or even fifteen feet. As to their origin, two hypotheses are discussed; one, to the effect that they are due to a greater rate of motion in the projecting layer of ice than in the layer immediately beneath; and the other, that the exposed edge of a dirt-stained layer melts back more rapidly than the similarly exposed edge of a stratum of clear ice. Either of these two explanations is considered as being applicable to the observed examples, and a choice between them does not appear to have been practicable.

While examining the glaciers on the Three Sisters, Oregon, on August 16, 1903, I found jutting layers of névé ice, on the vertical wall of a crevasse which seem to be a counterpart of those described by Chamberlin, a photograph of which is here reproduced.

The wall of ice, or rather granular névé, referred to, occurs near the head of a small glacier at the east base of West Sister, and occupies an amphitheater-like depression between West and North Sister. It is the upper or hanging wall of the highest crevasse which intersects the glacier or a *Bergschrund*, the lower wall of which had in part fallen previous to my visit, so as to leave its companion fully exposed. The wall faces east and is in shadow after midday, when melting ceases on its face. In reference to the stratification of the snow, presence of dirt bands, exposure to the sun, etc., the conditions present are similar to those pertaining to the glaciers of Greenland on the vertical walls of which cornices have been observed.

The escarpment shown on the accompanying photograph is

[1] *Bulletin of the Geological Society of America*, Vol. VI (1895), pp. 206, 207; JOURNAL OF GEOLOGY, Vol. IV (1896), pp. 589-91.

about twenty-six feet high, and is composed of the edges of layers of clean, stratified, granular snow, between which there are dirt bands ranging in thickness from a fraction of an inch to three or four inches. On the central part of the precipice, where fully exposed to the sun until noon each day, there are two conspicuous cornices which project beyond the surface below them in each instance from six to seven inches. The under surfaces of

FIG. 1.— Wall of a crevasse in the névé portion of one of the glaciers on the Three Sisters, Oregon, showing cornices above dirt bands. Looking northwest. August 16, 1903.

the projecting beds, where exposed, are slightly fluted at right angles to their length, but this is not a conspicuous feature. The precipice at its north end passes under an arch of snow which forms the roof of a cavern, and in the portion sheltered from the sun there is no jutting of the layer of snow above the lower of the two principal dirt banks, which is the only one extending into the cavern. Near the south end of the precipice, but not shown on the accompanying picture, the dirt bands are bent abruptly upward and become vertical, near where the névé joins the steep face of the mountain. In this portion of the precipice,

which is also fully exposed to the sky, melting is equal on each side of the dirt bands, and they appear as black streaks in the bottom of vertical V-shaped grooves five or six inches deep.

In the instances deseribed above it is evident that the cornices are due to the more rapid melting of the layer below a dirt band than of the layer above it. The evidence sustaining this conclusion is, briefly, that when a horizontal dirt band is traced from where it is exposed to the sun, and has a cornice above it, into the cavern where the sun's rays do not exert a direct influence the cornice disappears; and when followed to where it is vertical and fully exposed to the sky, melting is equal on each side.

The more rapid melting of the snow below than above a horizontal dirt band is evidently due to the absorption of the sun's heat by the dark material, as it is dislodged and washed downward so as to stain slightly the surface beneath. The dirt exerts this influence during its passage over the surface of the exposed edges of the layers of clear snow in the face of the precipice.

In addition to the direct evidence just presented favoring the hypothesis of differential melting to account for the development of cornices, indirect testimony in opposition to the hypothesis of differential motion is furnished by the fact that the distance from the *Bergschrund* to the head of the névé where it meets the steep upward slope of the mountain ranges from 50 to 200 feet, and, as is probable, there is practically no motion in the wedge of snow thus left clinging to the rocks. ISRAEL C. RUSSELL.

NOTE.—That differential melting is the chief factor in the formation of ice cornices, in most cases, may be accepted as established by such evidence as is presented in this article, and concurrent evidence elsewhere given. It is much less safe to assume that shearing motion is not a *contributing* factor in many cases, especially in the basal and terminal portions of ice tongues. It is quite unsafe to infer that this bears adversely on the doctrine of shearing, which rests on other grounds. It is altogether wholesome, however, to check, by such evidence as that presented in this paper, the too free inference of shearing motion to which the striking features of the cornices are liable to lead. T. C. C.